ON THE RELATIONSHIP BETWEEN MAXIMUM CONCENTRATION AND AVERAGING TIME. - G.P.N. VENTER & E. KEMENY

INTRODUCTION

The maximum concentration of any pollutant in the atmosphere for a given averaging time is of some interest because it is a measure of the highest dosage that will be received at the sampling point in that given period. Based upon this it would be of some value to be able to predict, for example, the mean maximum yearly concentration at a point if the maximum daily concentration is known.

GENERAL

McGuire and Noll (1971) investigated the relationship between maximum concentration and averaging time for five pollutants in 17 U.S. cities.

They found that this relationship can be expressed as

$$C_{max(t)} = C_{max(h)}\ t^{b}$$

where $C_{max(t)}$ is the maximum concentration over an averaging time of t hours, $C_{max(h)}$ is the maximum concentration over an averaging time of one hour and b varies with the type of pollutant as well as with sampling location.

Their results are summarised in tables 1 and 2.

TABLE 1

	CO	NO_2	Oxides of nitrogen	Oxidants	SO_2
Mean Value of b for 1967	-0,125	-0,217	-0,222	-0,251	-0,260

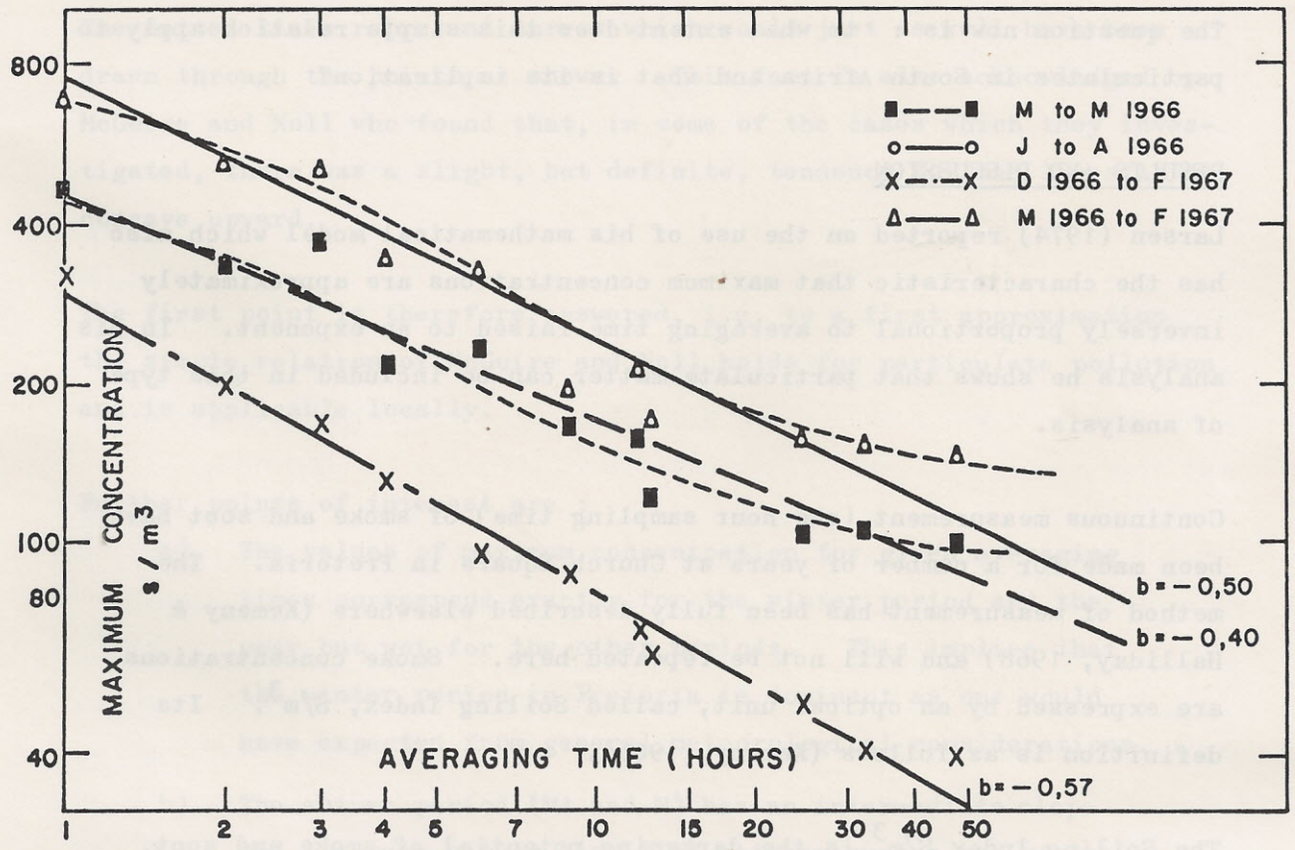

FIG. 1. *Maximum Concentration as a Function of Averaging Time*

TABLE 2

Oxidant variation for the period 1963 - 1967

Year	1963	1964	1965	1966	1967
b	-0,279	-0,298	-0,276	-0,268	-0,260

The question now is : to what extent does this simple relation apply to particulates in South Africa and what is its implication?

RESULTS AND DISCUSSION

Larsen (1974) reported on the use of his mathematical model which also has the characteristic that maximum concentrations are approximately inversely proportional to averaging time raised to an exponent. In his analysis he shows that particulate matter can be included in this type of analysis.

Continuous measurement (one hour sampling time) of smoke and soot have been made for a number of years at Church Square in Pretoria. The method of measurement has been fully described elsewhere (Kemeny & Halliday, 1968) and will not be repeated here. Smoke concentrations are expressed by an optical unit, called Soiling Index, S/m^3. Its definition is as follows (Kemeny, 1966).

The Soiling Index S/m^3 is the darkening potential of smoke and soot, suspended in one cubic metre of atmospheric air and collected on a circular area, 32 mm in dia., of Whatman No. 42 filter paper.

The Soiling Index may be converted into the gravimetric unit 'micro-grammes per cubic metre' by multiplication by a suitable conversion factor.

The data to be used here are for the period 1 March 1966 - 30 November 1968. Of these, four periods have been singled out :

a) Dec. 1966 - Feb. 1967 as representing the summer period

b) June 1966 - August 1966 as representing the winter period

c) March 1966 - Feb. 1967 as representing the annual period

d) March 1966 - May 1966 as representing the transient period

Figure 1 illustrates the result of this analysis. It is clear that, to a first approximation (in all cases except the summer), there is a log - log relationship between maximum concentration and averaging time. The dotted lines represent curves which could just as well have been drawn through the points as shown. This fact is also acknowledged by McGuire and Noll who found that, in some of the cases which they investigated, there was a slight, but definite, tendency for the lines to be concave upward.

The first point is therefore answered, i.e. to a first approximation the simple relation of McGuire and Noll holds for particulate pollution and is applicable locally.

Further points of interest are :

a) The values of maximum concentration for given averaging times correspond exactly for the winter period and the year but not for the other periods. This implies that the winter period in Pretoria is dominant as one would have expected from general meteorological considerations.

b) The autumn period (MA and M) has an intermediate slope and its peak values also lies between summer and winter. This implies that the atmospheric stability is not so severe as in the winter period and furthermore the atmospheric instability or dispersive capability is not so good as in the summer period.

c) The steep slopes - between -0,42 and -0,57 compared to the range of values by McGuire and Noll of -0,125 to -0,260 - indicates that, relatively speaking, the peak concentrations over short periods are very high

but that the variation is marked, leading to much lower values over the longer averaging times.

d) The fact that the slopes are approximately the same seems to indicate that in order to determine if there is an upward or downward trend in pollutant concentrations one should look at the maximum hourly concentrations over fixed periods for a number of years. However this conjecture should be investigated more fully.

e) A similar study on sulphur dioxide will be of value in assessing in general how South African cities compare to others.

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A ONE-DAY SYMPOSIUM ON MODERN PLANT DESIGN
HELD IN JOHANNESBURG ON 23rd NOVEMBER, 1973

OPENING BY THE DEPUTY MAYOR OF JOHANNESBURG, COUNCILLOR H.F. DEMMIS.

Dit is vir my 'n besondere eer en voorreg, en 'n groot genoeë, om saam met u by hierdie symposium teenwoordig te wees en dit te open met 'n paar woorde.

Eerstens wil ek verskoning maak vir die Burgermeester wat ongelukkig oorsee is.

Besides the Fuel crisis, which has stolen the limelight at the present moment throughout the world, Pollution of the Environment is about the biggest talking point today.

As far as towns and cities are concerned the most important aspect of pollution is that of stack emissions and the fouling of the air, and the public has been made so conscious of this menace that Town and City Councils dare not ignore it.

I believe that we in South Africa are extremely fortunate in being a young country as we are able, or should be able, to learn from all the mistakes and experience of the older countries. In fact we should never suffer problems to the same degree as other older countries. But I wonder if we do really take advantage of being in this unique position.

The first serious interest taken in South Africa in air pollution control was the establishment by the Air Pollution Research Group of the Council for Scientific and Industrial Research, of an Air Pollution Research Fund to which contributions were made by various interested parties. The Research Group organised conferences to which contributors were invited. The first semi-international conference was held in 1967. As a result of interest taken by various individuals in the Clean Air

Societies of Great Britain and the United States, it was decided in 1969 to form a NATIONAL ASSOCIATION FOR CLEAN AIR. It is a non-governmental association, devoted to securing throughout the Republic the maximum of natural light and air - free from every form of pollution.

Obviously this had to be the first step, and I would like to congratulate all those responsible for forming the Association, developing it, and maintaining the enthusiasm. In March this year the Association in conjunction with the Department of Health organised a very successful International Conference in Pretoria. Over 600 delegates, including many from overseas, attended the conference. Again, on the other hand, the Association has been represented at all International Council Meetings held since 1970.

As an independent organisation it forms an important link between the Government, Local Authorities and the General Public in the approach to securing "Clean Air".

I do believe that one of the most important steps in the Clean Air campaign is the public's interest, for without their awareness of the dangers and health hazards, it would be an arduous uphill struggle. People in towns and cities have developed a "learn to live with it" frame of mind. Fortunately, as I have said before, I believe the first step has been successful, and the public are not prepared to put up with these adverse conditions as a way of life in urban areas.

The Atmospheric Pollution Prevention Act was passed by Parliament in 1965 and a start made on its implementation in 1968. But real progress has only been made in the last two years. There are some 69 Municipalities in South Africa that are taking action in some degree or other.

In Johannesburg smoke control is fairly well advanced and there are indications that smoke concentrations are falling. One of the biggest problems facing most cities is the presence of African townships, where most cooking and heating appliances are oldfashioned butuminous coal

burning, and it is not easy to convert the African from this traditional form in his home. In addition one cannot ignore the economic problem of converting all these appliances to modern smokeless ones. The City Council of Johannesburg has done a tremendous amount to overcome this in Soweto by a campaign of advertising and financial assistance, but there is still a very long road ahead to achieve any real noticeable improvement.

For many years electricity was available to a large number of areas in Soweto, but the householder was not prepared to change from his traditional accepted way of life. Fortunately this is definitely but slowly changing, and the manufacturers of smokeless stoves must be congratulated on the manner in which they have tackled this technical problem and achieved splendid results without too heavy an increase in costs.

I believe too, that residents in the suburbs are beginning to co-operate and are taking advantage of the new appliances available, not only for themselves, but also for their living-in servants.

Enforcement in smokeless zones in the city is dependent, almost entirely, upon neighbours keeping a watchful eye on each other, and it appears that this is having the desired effect. That is why it is so important that the public are conscious of and in favour of the over-all efforts of the Authorities and the Association.

The importance of reducing emissions of smoke is indicated by the fact that Capital Expenditure on Air Pollution Control in the United Kingdom amounted to 150 million pounds for the ten years 1958 - 1968. In S.A. Iscor maintains that it will have to spend R120 000 000 on pollution control between 1970 and 1980, some 5% of total capital expenditure.

In terms of human lives, the cost has not been inconsiderable either. The worst incident was the infamous London "Killer Smog" of 1952 which caused an estimated 4 000 deaths.

The emission of smoke and offensive gases has, however, also concerned the man in the street for hundreds of years. In 1273 the use of coal in London was prohibited as being "prejudicial to health". The first legislation aimed at controlling the emission of noxious fumes and gases appeared in 1863. It is the follow-up to this ancient piece of legislation plus the British Clean Air Act of 1956 which formed the basis around which the South African Atmospheric Pollution Prevention Act of 1965 was framed. Thus industry has for many years had official prods to implement air pollution control measures. This has not been the only motivation for industries to reduce their stack emissions. Industrial pollution actually presents a classic example of what is known as an external diseconomy. This can only be removed if the polluter pays for his own waste disposal, i.e. if the costs are internalised. 'The Polluter pays' principle has been extensively adopted by developed nations and industries take cognisance of this.

Then industries often find it worth their while financially to cut down on their emissions. For instance, by installing a more efficient coal-fired boiler, an industry not only cuts down on the emission of dirty black smoke, but uses less coal for the same application. A better example may be provided by processes which emit sulphur dioxide in vast quantities. Instead of simply scrubbing the sulphur dioxide out, many firms convert it to sulphuric acid, and so provide themselves with additional sources of revenue.

Various methods of reducing stack emissions have been known to man for decades, and no new principle has been successfully applied to the collection of mists and dusts for over 60 years. The major developments in gas cleaning have been restricted to improvements in design and operating efficiency of existing types of collection equipment.

Perhaps the oldest air pollution control methods have been aimed at deodorisation of emissions. These stem from the use of bone char in the sugar industry as long ago as 1828, and the subsequent use of activated carbon as a means of trapping organic vapours.

Scrubbers, where emissions have to pass through water or other solvent sprays are also amongst the oldest methods for cleaning exhaust gases. This is a method which, by itself, is only successfully applied to instances where offensive vapour is very readily absorbed by the water or other solvent. If a solvent other than water is used, care has to be taken that the solvent itself does not emit offensive vapours.

A further gas cleaning apparatus is the cyclone separator which is used for removing grit and dust from emissions. This is one of the most important of the modern gas cleaning methods with research leading to the development of a multiplicity of different modifications for increasing efficiency. And finally, one of the most successful of all gas cleaning methods is electrostatic precipitation.

Now I am sure that you are all anxious to get along with your symposium when there will be a change of ideas and fruitful discussion on modern methods for stack emission control.

So I would like to say that it gives me tremendous pleasure in declaring your symposium open, and may I, on behalf of the City Council of Johannesburg and all it's citizens, wish you all a very successful and fruitful symposium, so that our environment may be all the more clean and pure from your efforts.